14

Milk harvesting and hygiene

This chapter discusses the key principles of good milk-harvesting practices to ensure high milk quality.

The main points in this chapter

- Milk composition and milk quality are often incorrectly used to mean the same thing; however, composition is the content of milk components while milk quality is a measure of the various contaminants in the raw milk.
- The various measures of milk composition and milk quality are described.
- The basics of good cleaning of milking equipment can be summarised as WATCH, namely: water, action, time, chemicals and heat.
- Good milk hygiene practices make it possible to produce clean, safe milk and dairy products with less than the ideal equipment and facilities that are generally found on small holder farms in tropical environments.
- Hygiene can be split into various milk-harvesting practices, such as health and personal hygiene, environmental hygiene, milking procedures and milk handling, and finally post-milking procedures.
- When using machines for milk harvesting, a good testing and maintenance program is essential to ensure quality milk and minimal udder diseases.

Milk is the most perishable of all farm produce. Unlike other animal products, such as meat, milk is frequently harvested in very unhygienic conditions, where all too frequently, the current practices of cleaning and sterilising the containers used for its collection and transportation leave much to be desired. Not only is bacterial contamination in buckets and milk cans a major problem, but, because the tropical environment encourages rapid growth of these bacteria, the prolonged time delays in cooling the milk to 4°C, reduce its quality even further.

The government legislation controlling milk-harvesting systems in countries with developed dairy industries ensure a consistently superior milk quality that is just not currently possible in most of the SHD farms throughout Asia. Good milk hygiene

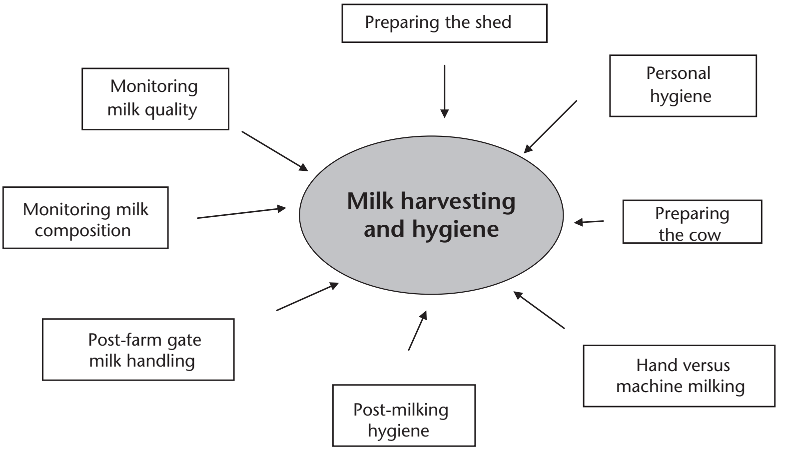
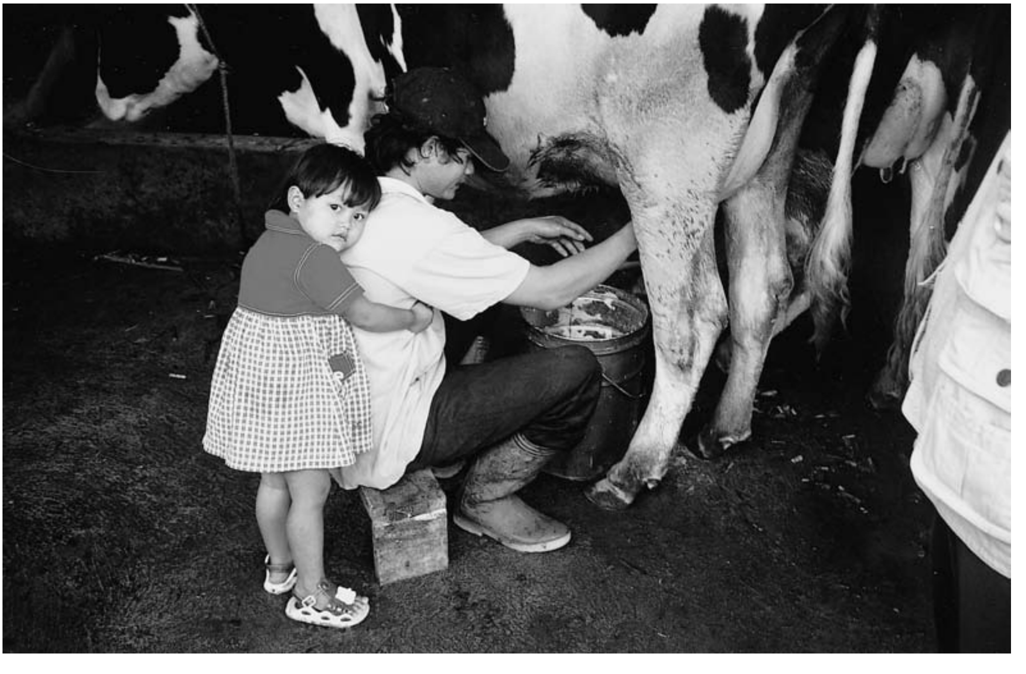


Figure 14.1. The key elements of good milking hygiene

practices make it possible to produce clean, safe milk and dairy products with less than ideal equipment and facilities that are generally found on small holder farms in tropical environments.

Good milk hygiene produces dairy products that are safe for human consumption, and that have good keeping quality. On the other hand, poor milk hygiene leads to spoiled products, product recalls (hence adverse publicity), food-borne diseases and



This milk bucket is not suitable for hygienic milk harvesting (Indonesia).

unsatisfactory or declining product image. This all leads to reduced consumer confidence in the integrity of the dairy value chain.

This chapter discusses milk harvesting, either using hand or machine milking, and the key aspects to ensure the integrity of the raw milk is not compromised by poor management and milk-harvesting practices.

14.1 Measures of milk composition and quality

14.1.1 Milk composition

This refers to the levels of total solids, milk fat and solids-non-fat or SNF (which include protein, lactose and minerals) in the milk. Milk hygiene, on the other hand, refers to the levels of various contaminants in milk, whether bacterial, chemical or any other adulterants that are detected. In many Asian countries, the term milk quality covers both composition and hygiene, whereas in Australia, it refers specifically to milk hygiene.

The **total solids (TS)** content in raw milk is estimated from its specific gravity using a lactometer, after adjusting for milk temperature. The results are not very accurate because the overall specific gravity is due to water, material less dense than water (milk fat) and material more dense than water (SNF). Therefore, milk with high fat and SNF content can have the same specific gravity as milk with low fat and SNF contents. Furthermore, milk temperature is sometimes not measured, meaning that cooler milk will have a higher specific gravity, hence a higher estimated TS content. If farmers leave their milk to cool before bringing it to a milk collection centre, it may have a higher estimated (and non-temperature-adjusted) TS content, but will also have higher bacterial contamination. The alcohol test can indicate this, thus allowing the milk to be rejected for poor quality.

Milk fat has traditionally been measured in the laboratory using a centrifuge to separate out the milk fat, which had been coagulated with a strong acid solution, although more modern techniques allow for rapid measurements. The **solids-not-fat** content is calculated as the difference between TS and milk fat. The **milk lactose** content is very consistent across all breeds and feeding management.

14.1.2 Milk quality

There are various ways and methods of monitoring milk quality, with the key ones described briefly below. Many of the methods are relatively inexpensive, with little needed in the way of equipment. Other methods may require more expensive equipment, but are more accurate and quicker.

The **total plate count (TPC)** measures the level of bacterial contamination that occurs after milking until the arrival at the milk collection centre or milk processors. It is one of the most common milk hygiene tests performed in the world. A small sample of the milk is taken and is placed with an agar growth medium. This mixture is then incubated for several days and the number of bacterial colonies that grow are counted, hence the name plate count. The greater the level of contamination, the poorer the keeping quality of the milk, and the less the farmer is paid for the milk.

The **methylene blue reduction test (MBRT)** is also a very common test for milk quality and is relatively easy to perform. It is similar to the TPC because it also measures the level of bacterial contamination in the milk. The initial mix of methylene blue and milk is blue in colour. As the level of oxygen diminishes in the milk due to bacterial activity, the blue colour changes to white. The time for this colour change indicates the level of bacterial contamination present in the milk sample. The shorter the time for milk to change colour, the more contaminated the milk.

The **resazurin test** is a 10-minute test to assess bacterial contamination through colour change, which is not as accurate as the MBRT, but is easier and quicker. The resazurin imparts a blue colour to the milk, which changes to pink and then to white over time in a hot water bath. After 10 min, the colour is compared with standards to assess milk quality.

Measuring **milk pH** helps to monitor whether compounds have been added to the milk to alter the specify gravity (and so falsely indicate higher levels of milk solids) or alcohol test, or mask the addition of water added to the milk to increase its volume. The pH should be 6.6–6.8. Lower values generally mean an acidification process due to bacterial growth, while higher values can indicate the presence of mastitis.

The **senses test (organoleptic)** usually involves trained operators tasting, smelling and visually assessing the milk consignment. It does not require any expensive equipment to perform, but is a subjective test. Any off-flavours, taints, smells and visible contaminants can be detected by a trained assessor.

The **milk temperature** is recorded at the milk processors from each tanker as it delivers the milk to monitor the degree of warming since it was first cooled, to 4°C, at the cooling plant.

In the **alcohol test**, milk is mixed with an equal volume of 68% ethanol and if it does not form floccules the milk is normal. If abnormal, the type of flocculent can indicate the type of contamination. Milk that coagulates is likely to contain high levels of acid, calcium or magnesium contaminants.

In the **clot-on-boiling test,** milk is boiled for 5 min to assess its heat stability. If it clots, it is likely to coagulate during processing (such as pasteurisation). This test measures the same characteristics as the alcohol test, but does not require the use of chemicals.

The **specific gravity** is measured using a lactometer to monitor both the milk composition (fat and SNF) and water adulteration. The density of milk is 1.028–1.034 at 15–20 °C and values below 1.028 usually indicate the presence of added water.

When raw milk is delivered to milk collection centres, it is routinely weighed then subjected to various ‘platform tests’ for contaminants, using the senses and alcohol tests. It can then be sampled and tested for specific gravity and fat content to monitor solids-not-fat content. MBRT and TPC (and resazurin) tests are generally measured in laboratories, rather than on the platform.

The major influence of milk composition is nutrition, breed and stage of lactation. Milk quality is the result of both intrinsic factors, such as mastitis infections, and extrinsic factors, such as :

- **the animal shed**, which should be clean, with a good supply of clean water and hot water

- **the animals**, which should be clean and have dried teats, and be checked for sub-clinical mastitis
- **the milker**, who should be healthy, wear clean attire, not smoke while milking, and use the correct milking techniques
- **the milking equipment**, which should comprise clean and sterile metal buckets that are stored upside down
- **milk storage and transport**; milk should be filtered before bulking and delivered rapidly to the milk collection centre in covered containers.

14.2 The science of milk quality

14.2.1 Factors influencing the growth of bacteria

It is important to understand the principles, firstly, of bacterial growth and, secondly, of cleaning and sanitising dairy equipment. This allows farmers to more competently and confidently consider local issues and find solutions to poor milk quality.

Bacteria have four basic requisites for growth, namely:

1. **Food.** Bacteria thrive in conditions supplying food and moisture, such as milk. Therefore, poorly cleaned utensils are ideal for bacterial growth.
2. **Warmth.** Although each species have optimal temperatures, they generally grow very well within the 20–40°C range.
3. **Moisture.** Most foods contain sufficient moisture for bacterial growth. Clean utensils should be stored upside down to facilitate drying.
4. **Time.** If provided with food, water and 37°C, bacteria will reproduce every 20 min. Each bacteria then can produce 500 new bacteria within 3 hr and 1 000 000 within 10 hr.

On farms where milk is not cooled until 1 or 2 hr post-milking, TPC levels can quickly become very large. Even when stored at 4°C, TPC levels increase, particularly if not delivered to milk processors within 1 or 2 days.

14.2.2 The principles of cleaning and sanitising dairy equipment

The cleaning and sanitising of milk-harvesting equipment are two separate and distinct operations that must go together to ensure minimal bacterial contamination. Put simply, cleaning removes residual milk from surfaces, whereas sanitising removes bacteria from cleaned surfaces. Basically, detergents are chemical removers of surface deposits. The general guide to cleaning is to:

- dry clean and remove all loose dirt and debris
- rinse or wet the surface, using cold or warm (not hot) water
- hot wash using a detergent solution that holds contaminants (or soils) in suspension for a short time
- rinse with cold water and drain
- apply sanitiser to contact surfaces and allow to dry.

The basics of good cleaning and sanitising dairy utensils can be summarised by the acronym WATCH**,** as follows:

- **W**ater. Water quality, such as the level of sediment or bacteria, is very important.
- **A**ction. This means using mechanical action (with pumps or vacuum) to encourage agitation, or manual cleaning, such as using a brush.
- **T**ime. It should be long enough for the chemical to work but not too long for redepositing of soils. The longer a surface is manually cleaned, the better. Cleaning in place (CIP) systems are the best because they require the least physical effort.
- **C**hemicals. The chemicals should be matched for the job, used at the recommended dilution rate and in the right sequence. Protective clothing should be worn if necessary.
- **H**eat. Chemical activity doubles for every 10°C over 50°C. Excess heat can denature some sanitisers.

Different types of detergents have different roles. Neutral detergents are the easiest to use because they require no skin protection. Alkali detergents remove protein, fats and carbohydrates, whereas acid detergents are best at removing milk stones and hard water scale. Good cleaning practices require regular use of both alkali and acid detergents. Their effectiveness is compromised when used in lower temperature water.

Milk stones are hardened deposits formed from residual milk, bonding to metal, rubber and plastic surfaces. Water high in dissolved minerals (hard water) will form a hard water scale. Both these residues provide a suitable environment for bacteria, which are released into any milk coming in contact with them. Milk stones will become more of an issue as hot water becomes more widely used.

To provide some guidelines on optimum water temperatures, Australian dairy cleaning standards are as follows:

- pre-rinse: not exceeding 50°C
- flush cleaning: 80°C
- acid cleaning: 80°C minimum
- sterilising: 90°C minimum.

14.3 Management practices for good milking hygiene

There are 20 key factors for small holders to produce clean milk. These are presented in Table 14.1, together with the associated on-farm practices.

These management factors can be split up into various milk-harvesting practices such as:

1. health and personal hygiene
2. environmental hygiene
3. milking procedures and milk handling
4. post-milking.

Table 14.1. Key factors and on-farm practices to undertake to produce clean milk on small holder farms

Key factors to produce clean milk	On-farm practices
Prepare the shed	Repair any holes in floor, clean the floor and wash with disinfectant
Personal hygiene	Use clean clothes, carefully wash hands; don't milk if you are sick
Prepare for milking	Have ready the udder cloths, buckets, stool, basket (for dirty udder cloths), strip cup, muslin cloth and milk can to save time; place milk can outside shed
Pre-milking cleanliness	Do not use milk containers for any other purpose, all equipment must be clean, sanitised and dry
Cow comfort	Gentle handling of cows, maybe offer some concentrate, but not roughage
Cow cleanliness	Brush cow to remove dust, wash udder and teats, and dry teats
Cow disinfection	Use one cleaning cloth per cow soaked in hypochlorite (1 teaspoon/5 L water)
Reduce disease transfer	Use one cloth per cow; put used udder cloths into separate basket; don't let milk drip/spill onto floor
Water quality	Only use good-quality water for washing cows and containers
Pre-milk each teat	Strip milk each teat into cup to check for mastitis and remove initial milk
Hand milking	Use fast steady speed, use 'hand squeeze' not 'hand strip' technique; don't use oil, water, milk or spittle as lubricant; use hand cream if necessary
Machine milking	Routinely replace rubber linings, sanitise after use; follow correct maintenance schedule; open tops of milk cans in cooling unit to facilitate heat dissipation
Timeliness of milking	Start milking within 30 seconds of washing udder, cow's let-down lasts 5–7 min
Teat dip	Dip each teat into iodine solution; can use all in cup if solution is still clean
Bulking milk	Quickly strain into milk can through muslin to remove contaminants; put lid on can
Cooling milk	Take milk to a milk collection centre for cooling as soon as possible; handle can gently
Post-milking cleanliness	Rinse all milking utensils in cold water, wash them with detergent and brush in hot water, rinse again in cold water, then rinse in disinfection or very hot water and place upside to drain
Reusing disinfectant	Do not reuse rinsing disinfectant solution for next milking
Drying of equipment	Leave utensils to drain on racks in a well-ventilated, clean, tidy place
Disease treatment	Use indicator paper or California mastitis test to detect sub-clinical mastitis; treat on same day as detected
Clinical mastitis treatment	Empty inflamed teat out every 2 hr, leave antibiotic in teat for 8 hr

14.3.1 Health and personal hygiene

People suffering from contagious disease, respiratory problems (such as a cold) or intestinal problems (such as diarrhoea) shed bacteria at greater than normal rates. To guard against the spread of disease, it must be assumed that everybody is potentially a disease carrier. People should not handle milk or hand milk cows if they have:

- sore throats or upset stomachs (diarrhoea and/or vomiting)
- skin infections (boils, septic pimples, rashes, etc.)
- heavy colds or fever
- any disease that may be transmitted by contamination of milk and dairy products.

To reduce the likelihood of contamination, anyone handling milk should be aware of bad or unconscious body habits and avoid the following:

- scratching any part of the body, face, nose, mouth, ears or hair
- coughing or sneezing directly onto milk or product
- touching, picking or squeezing pimples, boils or sores
- using spittle as a lubricant when hand milking (use hand cream if necessary)
- tasting milk or dairy products by using the fingers or a ladle that is returned to the product.

The key to preventing bacterial contamination of milk and dairy products is to keep the hands clean because they are by far the most common mode of contamination.

Hand washing. The procedure for washing hands is simple, yet is often not carried out correctly. Wash hands and forearms by:

- pre-rinsing to remove dirt and grime
- washing in a rich lather using soap and water
- brushing under the nails
- rinsing then drying with a disposable hand towel
- some Western dairy farmers routinely use disposable gloves at each milking.

Smoking. Do not smoke tobacco or any other substance when handling milk. Smoking causes:

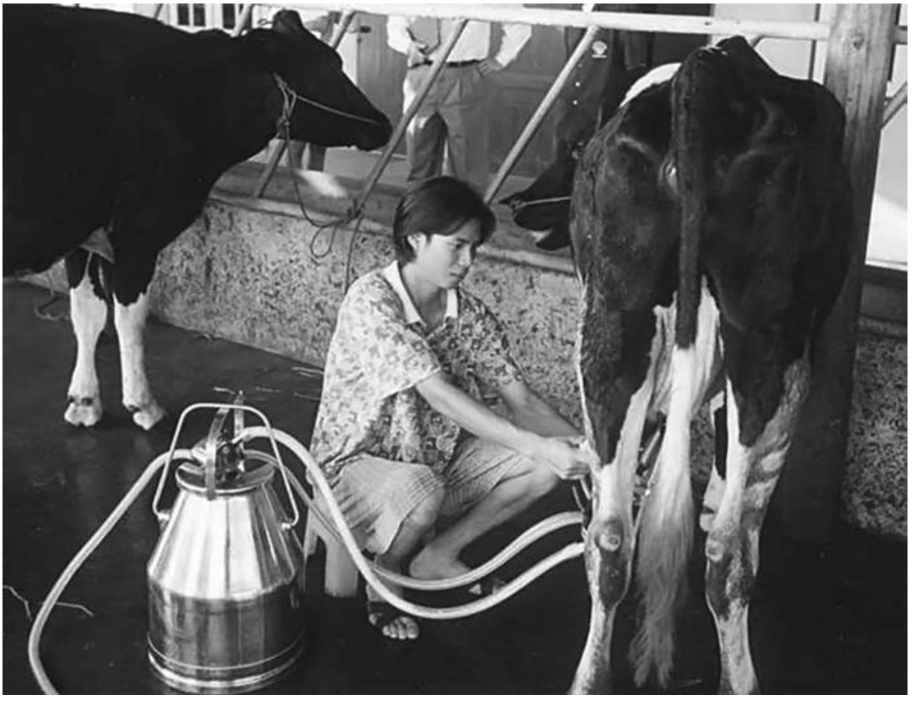
- direct contamination of food by ash or cigarette butts
- coughing
- contamination of food from fingers touching lips while smoking
- health issues for non-smokers (the effect of passive smoking is well documented).

Protective clothing. The use of hair coverings and gloves is recommended to keep hair and skin flakes out of milk and to prevent cross contamination occurring.

14.3.2 Environmental hygiene

Environmental hygiene relates to both internal and external environments. The external environment are those areas outside of the production area, while the internal environment refers to areas where milk and dairy products are produced, packaged and stored.

Environs. Sealed, graded and drained roads and grassed areas around the dairy and cattle housing will cut down dust contamination of the dairy. Adequate drainage of the dairy and housing is essential. Effluent (manure, mud and cleaning water) must be disposed of effectively. Regular (once or twice per week) removal and spreading onto farmland or pasture areas should be undertaken.



A well-managed milking system in Thailand.

Water supply. Sufficient quantities of clean drinkable water must be available for cleaning operations and a drinking supply for stock.

Rodents. Control can be a combination of the reduction of food and habitat, vermin proofing of structures, trapping and prudent use of chemical baits.

Flies, cockroaches and other insects. Insect pests carry bacteria and can transmit many diseases to humans. Control is the elimination of breeding and feeding places. Insect-deterrent lighting, electrocuters and sticky pads also have their place. Reliance on insecticides alone should be avoided.

Birds. They carry *Salmonella* and will contaminate buildings, water supplies and surrounds with faeces. Birds are attracted to dairy premises by the presence of cattle feed.

Animals and housing. These can be a major source of contamination if not kept clean. Grooming and clipping is important in reducing contamination from hair and dust on the animals. This is particularly important when hand milking. Animals should always be handled quietly and gently to avoid upsetting them. Upset animals always result in more dust and manure. Calves, young heifers or other animals (ducks, chickens, etc.) should not be housed in, or have access to, the dairy.

People. The potential for workers to bring contamination on clothing, footwear and on the person is always a possibility.

Internal environment. The dairy should be a dedicated building for milking. Cattle feedstuffs, chemicals or medications should not be stored in the dairy (except for cleansers and sanitisers). If feeding concentrates at milking, they should be stored outside the dairy and only brought in to feed cows at milking. Roughages should not be fed during milking. Dust and spillage of feedstuffs should be minimised.

The actual milking and milk-handling areas of the dairy need special attention. The floor should be an impervious surface (such as concrete), and maintained in good repair. It should be kept clean both during and at completion of milking. Dairy equipment and facilities such as wash up troughs and drainage racks need to be constructed of non-absorbent, corrosion-resistant materials, such as stainless steel.

14.3.3 Milking procedures and milk handling

Dairy/milking area. The milking area should be kept clean. Thorough cleaning following each milking session is essential. Floors should be swept and/or washed with water so as to be visibly clean.

Equipment. Teat cloths, buckets, stools, waste/dirties bucket, strip cups, teat dip and milk storage equipment all need to be clean and ready to use. Any equipment coming into contact with milk, such as buckets, milking machines and storage vessels, should be sanitised and allowed to drain for at least 15 min prior to use.

Cow handling and preparation. Good cow handling and preparation should begin before she is brought to the milking area. Gentle handling at all times is essential and, with some, grooming, if hand milking, is necessary. Slapping or striking the cow with the hand or objects such as sticks or canes should be minimised. Consistent use of even moderate slapping or hitting will result in the cow becoming fearful and upset. This will negatively effect milking because it interferes with the 'let-down' response.

Offering concentrate can be an excellent way to entice cows into the milking area, but it should be done consistently at every milking. Only give a set amount of concentrate at each milking. Offering cows more some days and less at others is likely to upset them.

Foremilk stripping. Teats should be striped into a strip cup to check for mastitis/abnormalities in the milk for at least a month (and preferably longer) into the lactation.

Teat preparation. Teat cleanliness is essential prior to milking. Dirty teats should be washed with clean running water (at low pressure) and then dried with clean, individual towels (paper or cloth). If the udders and teats are consistently dirty at each milking, the cows' environment requires closer attention.

Milking. At least 30 seconds from the start of teat handling should be allowed before hand milking. This provides adequate time for the 'let-down' response to occur. Milking should be complete within 5–7 min. Hand milking should be quick and gentle using a squeezing action rather than a pulling or stripping action. If milkers insist on using lubricants, then only allow them to use hand cream.

Hand milking technique. The most common milking technique is 'hand strip' milking for the entire milking cycle, rather than the accepted, and presumed better, alternative 'hand squeeze' method. Udder and teats are washed with a cloth but left wet to facilitate lubrication for strip milking. The cow is strip milked either one-quarter (one handed) or two-quarters (two handed) at a time. The 'hand squeeze' method more closely mimics the natural calf sucking reflex, which seals the top of teat with the lips and squeezes the teat with the tongue. The strip milking technique, combined with a non-dry udder, leads to additional bacterial loading to the milk in the bucket as the water on the teats acts as a vehicle and stripping helps push the water into the bucket.

Strip milking will also leave the teats moist, loosen the bacteria around the teat skin and provide a vehicle, via water and stripping, to bring bacteria close to the open teat orifice. The absence of teat dipping means there are always bacteria readily available to enter the teat post-milking. Strip milking is much more likely than squeeze milking to cause epidermal micro erosions that harbour mastitis bacteria.

14.3.4 Post-milking

Milk filtering. Immediately following hand milking, the milk should be filtered into a clean, sterile storage container. The filter cloth should be thoroughly cleaned in detergent and sanitiser then dried in the sun.

Milk storage/cooling. It is vital that milk is chilled to below 3–4°C as soon as possible after milking.

Milk transport. For small holders without refrigeration, milk needs to be transported carefully and as soon as possible after the completion of milking and cooled immediately at the milk collection centre. Heat, light, excessive movement and time all cause deterioration in warm milk. Transport containers should be clean, sanitised and able to be sealed with lids. They should be made of food-grade materials, which are capable of being cleaned and sanitised properly.

14.4 Milking machine function and maintenance

14.4.1 Milking machine components

Vacuum pump. This is an air pump or air compressor that removes air entering the milking machine through the various components such as the teat cups and pulsators. The pump must have sufficient capacity to remove all this air, as well as enough spare capacity (reserve or effective reserve) to maintain the vacuum at a pre-set level. It must also be able to return vacuum levels quickly to these levels following air admissions, which occurs, for instance, when cups are removed or fall off a cow.

Regulator. This simply regulates the vacuum level in the milking machine. Desirable features for a regulator are an ability to quickly regulate changes that occur in the vacuum levels of the milking machine during operation. Vacuum levels in milking machines are generally set between 40–50 kPa depending on the type of machine and equipment set up. A good rule of thumb is that vacuum levels be set as low as possible. Cup slips indicate that the level is too low.

Pulsators. These involve a valve mechanism that alternates vacuum and atmospheric pressure in the chamber between the teat cup liner and the shell of the teat cup. The cyclic pressure changes cause the liners to move within the teat cup.

The pulsation rate is the number of times the teat cup liners complete a pulsation cycle in 1 min. An ideal range for the pulsation rate would be around 60 cycles/min ± 2 cycles. Acceptable rates can go as low as 50 cycles/min but should not exceed 62. The pulsation ratio refers to the portion of time of the vacuum phases that occur during each pulsation cycle. A pulsation cycle is divided into four main phases:

- The increasing vacuum phase (**a phase**) is when the vacuum level in the chamber between the liner and the shell is increasing from atmospheric pressure to machine vacuum level. Milk begins to flow from the teat end during this phase.
- The maximum vacuum phase (**b phase**) occurs when full vacuum is achieved in the chamber. During this phase, the liner is fully open and milk will be flowing from the teat end.
- The decreasing vacuum phase (**c phase**) occurs when the pulsator valve opens the chamber to atmospheric pressure causing the liner in the teat cup to begin collapsing under the vacuum within the liner. Milk flow will cease during this phase.
- The minimum vacuum phase (**d phase**) is when the chamber is at atmospheric pressure. The liner is fully collapsed and exerting maximum pressure on the teat.

14.4.2 Testing milking machines

With all types of machines, the pump should be run for 5–10 min before testing commences. This allows the pump and machine components to reach full operating efficiency.

While the machines are warming up, a visual inspection can be carried out.

Check that:

- the guards over belts and pulleys are in good order
- the electrical wiring and installation is not worn and cut-out devices are operable
- the vacuum pump oil feed and mounting are satisfactory with little vibration during operation
- the vacuum regulator is mounted according to manufacturer's recommendations and is subject to vibration
- the vacuum gauge is fitted between the regulator and the first pulsator and were it can be read easily by the operators
- the rubberware is in good condition and free from cracks and holes
- the air admission holes on the claws are not blocked
- all air filters on regulators and pulsators are clean.

Pulsators. The important characteristics to test for and measure are the pulsation rate, ratio, and actual time of the d phase. Pulsation rate is generally acceptable in a range of 50–60 cycles/min.

Pulsation ratio characteristics that are monitored closely are the d phase and the b phase. The d phase should reach atmospheric pressure for at least 15% of the cycle and be not less than 0.15 seconds in duration. The d phase, also called the 'squeeze phase', is very important in maintaining good teat health. The b phase should not be less than 30% to ensure an optimum milk removal rate from the teat.

If there is more than one pulsator, a tolerance of 5% difference should not be exceeded in pulsation characteristics between all pulsators on the plant.

Vacuum levels. The working vacuum level is controlled by the vacuum regulator. Although there is no formal specification for the working vacuum level for most systems, a level of between 40 and 50 kPa is acceptable. The capacity of a vacuum pump to maintain vacuum levels is critical. As a guide for bucket milking plants, a basic allowance of 150 L/min, plus 60 L/min for each set of teat cup units, is a standard pump capacity. This standard allows for all the consumption requirements of the milking machine, as well as providing an allowance for an effective reserve. All effective reserve measurements at testing are recorded at a standard 50 kPa. The vacuum gauge can be checked for accuracy over a range of vacuum levels from 40 to 55 kPa and the working vacuum level set for the machine should be marked on the gauge.

14.4.3 Routine maintenance

Listed below are some basic maintenance requirements to keep a milking machine in sound operating condition.

Vacuum pump. Most pumps will have oil lubrication systems that need to be kept topped up. Manufacturer's recommendations should be followed. The drive belts should be checked for wear and cracking and pulleys should be aligned.

Pulsators. Most pulsators used on bucket milking plants are integral systems operated by vacuum and are mounted on the milking machine so as to access the vacuum. Once again, manufacturer's recommendations should be followed regarding maintenance needs. Generally this requires regular cleaning of air filters, depending on how dusty conditions are, and regular maintenance of working components within the pulsator.

Regulator. Once again, large volumes of air flow through the air filter on the regulator and it should be cleaned routinely. Manufacturer's guidelines need to be followed with regard to the maintenance requirements of the regulator.

Rubberware. From the functional aspect of a milking machine, the most important piece of equipment on the machine is the liner or inflation. The inflations are the only part of the machine that comes in contact with the cow. From the day they are fitted to the milking machine, they begin to deteriorate and lose their flexibility. A good rule of thumb is to replace the inflations after 2500 milkings, using the following simple formula:

$$\text{Replacement age (days)} = \frac{2500 \times \text{number of claws}}{\text{herd size} \times \text{milkings/day}}$$

Therefore for a 40-cow farm milking twice daily, with one mobile milking machine with two claws, the rubberware should be replaced every (2500 × 2)/(40 × 2) or every 62 days.

Apart from functional aspects of the inflation, the other concerns are the milk-quality problems caused by deteriorated rubberware. Long milk rubbers should also be replaced regularly (usually every 9–12 months).